3. User Feedback

3.1 User Feedback Approach

During the phase 4 P & S prototype, comments and issues raised by the science and flight operations community were acquired in various ways. During the PRR demonstration, as well as informal demonstrations of the phase 4 P & S prototype, raised questions and comments were recorded. In addition, issues that surfaced during splinter meetings with the ECS PRR attendees were documented for later review.

3.2 Results To Phase 1 User Issues and Responses

Table 3-1 summarizes the primary issues pertaining to the phase 1 P & S prototype. In the table, an originator number corresponds to the source of each issue. The following originator categories are identified:

1 - Instrumenter
2 - Spacecraft Manufacturer
3 - Flight Operations Team
4 - Project

After review and analysis, a response was demonstrated through the P & S phase 2 prototype for each of these primary issues.

Table 3-1. Phase 1 User Feedback Results (1 of 3)

Issue	Orig	Response	Rationale
Establish initial command management interface	3	Developed the interface design with command management. Incorporate initial interface concepts into the phase 3 prototype.	Command management is one of the primary interfaces with P&S. By prototyping the initial concepts of this interface, potential risks can be minimized.
Provide a preliminary detailed activity schedule	4	Established initial format and contents of a detailed activity schedule by the phase 2 prototype, based upon discussions with command management. Provide initial detailed activity schedule in Phase 3 prototype.	The detailed activity schedule is the primary P & S product. By establishing an initial format and content, early feedback can be acquired from command management and other FOS elements.

Table 3-1. Phase 1 User Feedback Results (2 of 3)

Issue	Orig	Response	Rationale
Represent timeline activities at the command level	4	Developed design concepts with command management. Establish initial timeline command representation for a single instrument by the phase 3 prototype.	Prototyping the timeline command representation for a single instrument will provide the instrument community a conceptual demonstration.
Establish the preliminary ASTER interface concepts	1	Established initial ASTER interface test driver for phase 2 prototype.	The ASTER interface presents a critical risk for the P&S system. Providing an early P & S test bed for the ASTER interface will help mitigate these risks.
Architecture flexibility in allowing an external element to provide their own P & S components	4	Section 2.3.2 refers to the P&S IPC approach for handling external element message passing over the network. Ongoing discussions are taking place with instrument groups (primarily MISR and ASTER) for defining external P & S components. In addition, the phase 2 prototype incorporated an initial ASTER interface test driver.	Because instrument groups may be providing their own P&S components (e.g. ASTER), the P & S architecture must have the flexibility to incorporate them. As details are established, evolving interface test drivers will minimize the impact of these external components.
Incorporate the complete instrument manifest into the P&S prototype	1	For the phase 2 prototype, all AM-1 instruments were represented in the P & S system	Establishing an initial P & S representation for all AM-1 instruments will allow scheduling features to evolve as details are established from the instrument community feedback.
Response of the system to sudden TDRSS contact changes	2	Established a preliminary operational scenario that demonstrates the concepts and potential software tools for handling TDRSS contact times in the phase 2 prototype. Additional concepts and preliminary tools to respond to sudden TDRSS contact changes to be incorporated into phase 3 prototype.	TDRSS contact changes will affect data management, potentially resulting in loss of data. Providing tools for operator recovery will minimize impact. Early conceptual approach will provide science and flight operations community feedback into design.

Table 3-1. Phase 1 User Feedback Results (3 of 3)

Issue	Orig	Response	Rationale
Provide 2-D plots on the timeline display for representing SSR data volume and power consumption.	3	Developed 2-D line plots on the timelines for the phase 2 prototype to represent SSR data volume. In addition, developed histogram plots on the timelines for power consumption (shown at PRR).	Presenting data volume, power and other resources as graphical information (e.g. 2-D plots) will aid operator interpretation of mission resources.
Incorporate a graphical map analysis tool into the P & S system	1	Initial map analysis tool for the phase 2 prototype was presented at the PRR.	Displaying mission resources over space and time will benefit user analysis. By incorporating an early map tool, features will evolve based on input from the instrument groups.
Enhance the timeline display to reflect the scheduling needs of the instrument community	1	Incorporated timeline concepts for AM-1 instruments for phase 2 prototype. Currently, there are ongoing interaction with the instrument groups for defining their individual scheduling needs. Based on feedback, incorporate display concepts into phase 3 timeline prototype.	The varying scheduling needs of the instrument community will require a flexible timeline process to incorporate evolving display features.
Allow user control in tailoring the look and feel of the timeline display	1	For phase 2 prototype, incorporated simple tailoring of the timeline display through configuration files. Allow interactive user control for phase 3 timeline prototype.	Simple tailoring of the P & S displays (e.g. timeline) represents one of the primary user needs for performing day-to-day operations. By avoiding the hard coding of display features, the user can control their environment through interactive display selections and configuration files.
Transition the graphical user interface from Openlook to MOTIF	4	Ported P&S prototype to MOTIF for phase 2.	As established by the Common Open Systems Environment, MOTIF represents the primary GUI standard for running in a heterogeneous workstation environment.
Utilize paper scenarios to provide a complete thread through the P & S system	3	Scenario demonstration for presenting P&S concepts (e.g. timeline displays) was presented at the phase 2 PRR.	Providing scenarios of display concepts will allow early user feedback without the need for software prototypes.

3.3 Phase 2 User Issues and Responses

Based on the feedback provided by the science and flight operations community, Table 3-2 shows the issues pertaining to the phase 2 P & S prototype. In the table, an originator number corresponds to the source of each issue (refer to section 3.2 for originator categories). After review and analysis, a response was determined by the P & S team for each of these primary issues.

Table 3-2. Phase 2 User Issues and Responses (1 of 3)

Issue	Orig	Response	Rationale
Focus prototypes on risk areas.	2	Phase 2 prototype addressed several areas of risk (Section 2.1 and 2.2) including the ASTER and NCC interface (Section 2.3.1), distributed scheduling (Sections 2.3.1, 2.3.2, and 2.3.3), and evolvability (Section 2.3.4). The phase 3 prototype plans will address additional areas of risk including the CMS interface and baseline activity profile development.	The ASTER/NCC interface presents a critical risk for the P&S system. Providing an early P & S test bed for the ASTER/NCC interface will help mitigate these risks. Because instrument groups may be providing their own P & S components (e.g. ASTER), the P & S architecture must have the flexibility to incorporate them. As details are established, evolving interface test drivers will minimize the impact of these external components. Command management is one of the primary interfaces with P&S. By prototyping the CMS interface concepts, potential risks can be minimized.
Provide a flat map with target pointer to output a list containing orbits with ground track across target point.	1	The Phase 2 map analysis tool prototype provides a 2-dimensional map projection and displays geographically related data (Refer to sections 2.3.1.3 and 2.4.2.3). In addition, the scheduling analysis tool provides the capability to overlay spacecraft related data (such as ground tracks and instrument FOVs) onto the map projection. Currently, a user can determine visibility opportunities to targets by manually changing view times.	Displaying mission resources over space and time will benefit user analysis. By incorporating an early map tool, features will evolve based on input from the instrument groups.

Table 3-2. Phase 2 User Issues and Responses (2 of 3)

Issue	Orig	Response	Rationale
Investigate impact of the proprietary nature of DELPHI software.	4	DELPHI is a licensable product, which is maintained by Hughes and currently used on approximately 10 programs.	The DELPHI class libraries embody concepts and design elements based on several mission management systems. This code has been thoroughly tested, thus reducing overall life cycle P&S costs.
Identify any needs for multi-mission resource management and implement the necessary hooks	3	The phase 2 prototype provides the necessary hooks to re-use common behavior among multi-mission resources (e.g. instrument types, power subsystems) (for further details, refer to section 2.3.4)	A flexible, extensible object class structure that will support future system upgrades and changes is necessary for an evolvable system.
Establish some examples of the interface with the command management subsystem	4	Currently defining the interface with command management. Incorporate initial interface concepts into the phase 3 prototype.	Command management is one of the primary interfaces with P&S. By prototyping the initial concepts of this interface, potential risks can be minimized.
Integrate P & S prototype with User Interface IST prototype.	3	Coordination is currently taking place with the User Interface IST for integrating the prototypes by the phase 3 prototypes.	Establishing the interface between P & S and User Interface IST is necessary for providing the IST with an integrated set of FOS tools.
Transition to DCE for distributed communication and study role of CORBA.	4	Coordination is currently taking place with CSMS for integrating DCE into the phase 3 prototype. We are also investigating the role of CORBA to provide distributed P&S processes.	Establishing the DCE interface in P & S for distributed communication is necessary for providing the IST with an integrated set of FOS tools using CSMS as the infrastructure. The migration path to CORBA may play an essential part with the CSMS infrastructure.
Map display colors are difficult to look at.	1	The phase 2 map analysis tool prototype provides the capability for the user to select display colors.	Simple tailoring of the P & S displays (e.g. map) represents an important user need for performing day-to-day operations. By avoiding the hard coding of display features, the user can control their environment through interactive display selections and configuration files.

Table 3-2. Phase 2 User Issues and Responses (3 of 3)

Issue	Orig	Response	Rationale
Provide information sharing between ISTs and EOC.	1	The phase 2 prototype presented a common toolset at local (EOC) and distributed (IST) nodes that graphically depict the state of the mission plan, thus providing global visibility into spacecraft subsystem and instrument plans/schedules.	Global visibility into the P & S information represents one of the primary user needs for performing day-to-day operations. Visibility into all schedules allows for early conflict resolution.
Provide local control of locally owned resources.	1	The phase 2 prototype provides a common toolset at all nodes that allows for local control of locally owned resources. For example, a PI/TL at their IST can modify their instrument's schedule by building activity deviations (refer to sections 2.4.1.1 and 2.4.1.3). For resources not locally owned, the user can only view (read-only) the plans and schedules.	Local control of locally owned resources with global visibility into the P & S information represents one of the primary user needs for performing day-to-day operations. Visibility into all schedules allows for early conflict resolution.

3.4 Phase 3 User Issues and Responses

Based on the feedback provided by the science and flight operations community, Table 3-3 shows the issues pertaining to the phase 3 P & S prototype. In the table, an originator number corresponds to the source of each issue (refer to section 3.2 for originator categories). After review and analysis, a response was determined by the P & S team for each of these primary issues.

Table 3-3. Phase 3 User Issues and Responses (1 of 3)

Issue	Orig	Response	Rationale
Focus prototypes on risk areas.	4	Phase 3 prototype addressed several areas of risk including FOS internal interfaces (Sections 2.3.1.12, 2.3.1.13, 2.3.1.14).	The FOS internal interfaces present a critical risk for the P&S system because of early release requirements. Providing an early P & S test bed for the FOS internal interfaces will help mitigate these risks.

Table 3-3. Phase 3 User Issues and Responses (2 of 3)

Issue	Orig	Response	Rationale
Provide the capability to handle a general list of constraint types since many of the spacecraft and instrument constraints may not be known until spacecraft integration and test.	2	The Phase 4 prototype will explore different methods for handling constraint checking including using pre-existing systems such as BPARR, WIND/POLAR, CLIPS and other COTS products as well as developing code in-house to handle mission constraints already identified.	Exploring external scheduling, rule-based and expert system software packages will reduce the risk of developing constraint checking code from scratch.
Various instruments may schedule activities based on orbit event triggers that include lat-lon regions and orbit cycle numbers.	1,2	The Phase 3 prototype began to address the scheduling of activities using FDF obtained orbital events. Three events were modeled, TDRSS availability, sunrise and sunset events. The Phase 4 prototype will utilize that data in scheduling most of the instrument activities.	Given feedback over the first 3 prototyping phases, it was determined that the majority of instrument teams and the FOT schedule activities triggered by a variety of orbital events. Prototyping scheduling methods using orbital events helps provide refined feedback from the user community.
Provide performance checks on the distributed architecture of the P & S system.	2	The phase 4 prototype will investigate distributed resource models. The current design has one main resource model located at the EOC. By distributing the resource model process, greater performance should be realized. In addition to distributing the resource model, limiting the data that is distributed to the ISTs (e.g. the "Master" plan only) should also increase the overall performance of the distributed system.	The distributed nature of the P & S software objects could exact an ugly toll on the performance of the system since IST sites are constantly receiving updates. Distributing the resource model and limiting the data flowing throughout the system will solve any performance problems encountered.
Provide the capability to view commands.	1,2,3	The phase 4 prototype will establish various methods for viewing commands. Some of the methods include viewing commands on the timeline, allowing users to view commands contained within activities by bringing up the command editor (Section 2.3.1.8.1) and the command list generated by CMS.	By providing a number of methods for displaying commands, user feedback can be obtained as to their usefulness. In addition, many groups expressed interest in seeing the actual commands at three times during scheduling: before, during and after.

Table 3-3. Phase 3 User Issues and Responses (3 of 3)

Issue	Orig	Response	Rationale
Establish a design for handling the archiving of the data used by the P & S system.	4	A number of designs will be explored for storing data used by the P & S system. These designs may include tools for determining the partitioning of the schedule.	Because the P & S software deals with continuous plans, risk mitigation involving the partitioning of the schedule must be studied. The manner in which the loads are partitioned by CMS will play a key part in determining the partitioning. In addition, archiving off old portions of the plan will aid in performance of the system.
Transition to DCE for distributed communication and study role of CORBA.	4	Initial coordination took place with CSMS for integrating DCE into the prototype. Phase 4 will test the integration. We are also investigating the role of CORBA to provide distributed P&S processes.	Establishing the DCE interface in P & S for distributed communication is necessary for providing the IST with an integrated set of FOS tools using CSMS as the infrastructure. The migration path to CORBA may play an essential part with the CSMS infrastructure.
Determine the method for scheduling instrument microprocessor load uplink periods.	4	A new uplink scheduling tool will be developed to provide instrument teams who are generating instrument microprocessor loads with a tool for requesting uplink periods.	Prototyping a tool that enables instrument teams to request uplink periods will help in eliciting feedback into how those teams will want to schedule uplink times.
Establish a operations concept and corresponding supporting software design for handling the reception of FDF planning aid data.	3	During the phase 4 prototype, a method for handling the reception of FDF data will be determined. If necessary, software tools developed to handle importing the data into the P & S system and the possible shifting of activities to correspond to any changes in the refined orbit event times.	Since most activities will be scheduled relative to orbit events, the ingest of FDF planning aids could have a significant impact on the absolute times within those activities. A method for handling this needs to be established.
Refine the procedure for rescheduling activities that have been bumped from the schedule.	4	An automatic scheduling tool will be prototyped which collects activities that have been unallocated and the capability to reschedule those activities using an uncomplicated algorithm.	A software design needs to be established to be able to manage activities that have been removed from the schedule because of simple unallocation or impact scheduling.

3.5 Phase 4 User Issues and Responses

Based on the feedback provided by the science and flight operations community, Table 3-4 shows the issues pertaining to the phase 4 P & S prototype. In the table, an originator number corresponds to the source of each issue (refer to section 3.2 for originator categories). After review and analysis, a response was determined by the P & S team for each of these primary issues.

Table 3-4. Phase 4 User Issues and Responses (1 of 2)

Issue	Orig	Response	Rationale
Instrument teams as well as flight operations team wants to be able to get a listing of commands.	1,3	A command resource will be added to the resource model to provide basic modeling of the onboard command buffer. Since it is planned to have the plan tool able to generate reports on what states and activities exist in the resource model this will provide the needed functionality.	Since the resource model provides the basic modeling of the system for P&S, it will be a straight-forward process to add a command buffer resource. Current designs for the plan tool include the "print" functionality and should generically be able to handle the printing of the command states in the resource model.
What types of constraints will be handled by P&S and what will be the design?	1	Generic temporal constraints will be provided. Additional constraints requiring special code will be handled in the schedulable resources portion of the resource model.	Since a generic temporal constraint checking mechanism has already been prototyped, these types of constraints will be covered. The schedulable resources in the resource model were designed (from the Delphi heritage s/w) to handle special constraints. Early identified special constraints will be placed there as will later ones but may require change requests.
Confusion still exists as to what an activity and a activity definition is.	2	The definition of an activity will be clarified and the timeline will be modified to be able to display the command blocks associated with an activity definition.	By allowing users to see and understand what commands are being executed should help alleviate confusion.
The reception of planning aids files obtained from the FDF should be placed in one directory location.	4	All files from the FDF will be received by the FOS at one location and initially processed by the DMS. P&S will no longer interface directly to the FDF.	Creating one location and one entity within FOS to interface with the FDF will simplify the transaction that must occur between both parties.

Table 3-4. Phase 4 User Issues and Responses (2 of 2)

Issue	Orig	Response	Rationale
The amount of power and solid state recorder buffer usage at any point in time should be related to the mode, not activities.	2	The power and data buffer usage will be placed into the mode table instead of associating them with the activity definitions.	Since the S/C manufacturer is requiring that the instrument teams provide them with power and data buffer usage associated with modes, the P&S software will follow suit.
Will users be able to schedule activities on top of other activities on a individual resource?	3	Two different types of allocators will be created and used depending upon what type of resource is being scheduled. One activity allocator allows overlap, the other does not.	Certain resources that may represent a collection of smaller resources should have the capability of having overlapping activities. Other resources, such as most of the instruments should not allow overlapping activities.
Plan differencing may be needed.	2	Event messages will be sent to DMS from the various scheduling tools and resource models detailing activities that have been added and deleted from the mission schedule. In addition, an activity recycler process will collect activities removed from the schedule.	Differences may be determined by viewing the event messages as well as viewing the timeline and perusing activities in the activity recycler.

4. Summary

4.1 Summary

The P & S Prototype Results Report presented the design, architecture and features of the phase 4 P & S prototype effort. A distributed P & S system was refined on the already existing architecture that consisted of independent, distributed C++ processes that communicated by passing object oriented messages between each other. In order to handle changes in the mission requirements and operational concepts, the object oriented infrastructure was further refined, taking advantage of the P & S experience contained in the Mission Planning Class Libraries and from other heritage systems.

Since this is the last prototyping phase before full-scale development, much of the feedback obtained from this prototype will be incorporated into the design and eventually in to the final system.

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Appendix A. P & S Class Hierarchies≠

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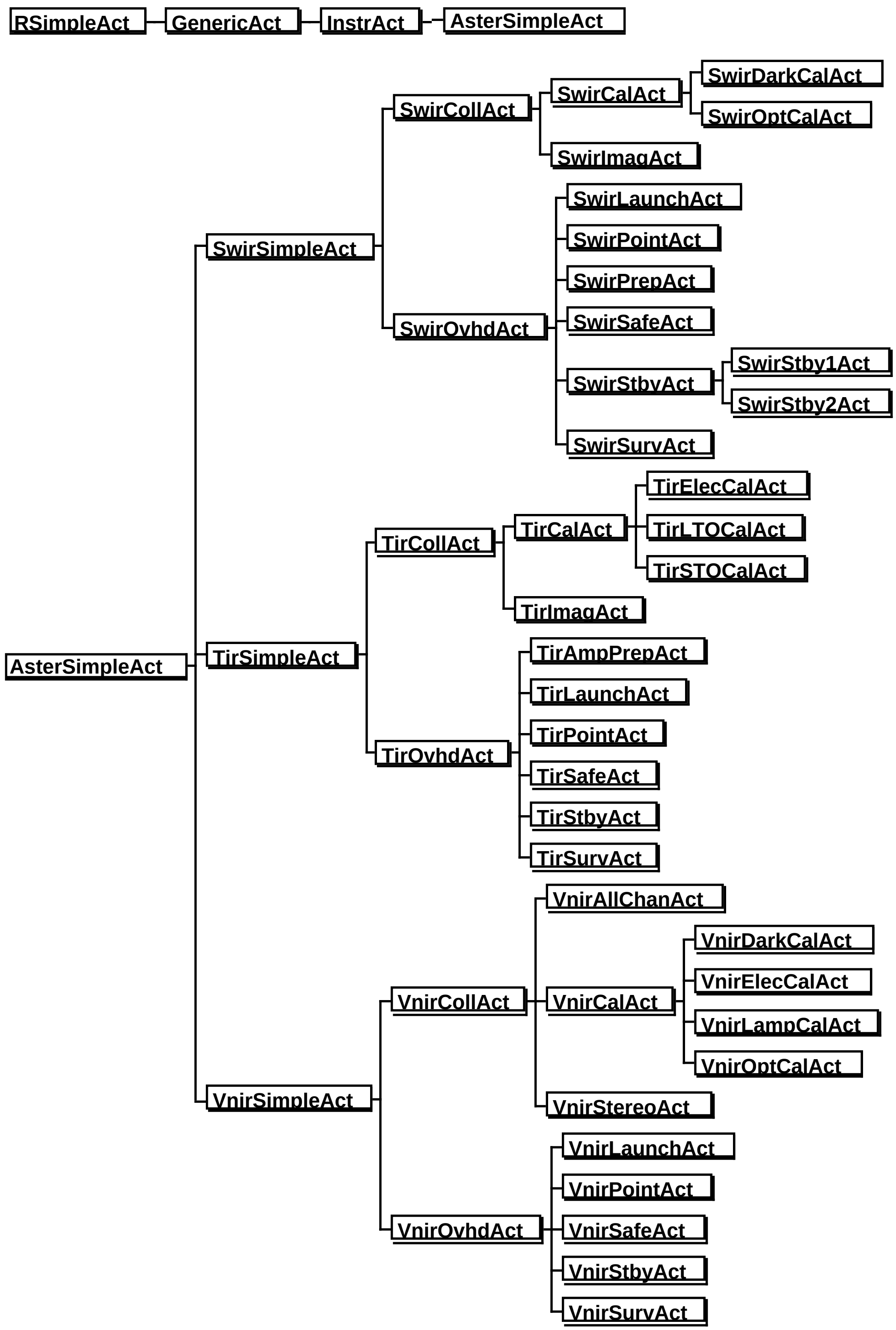
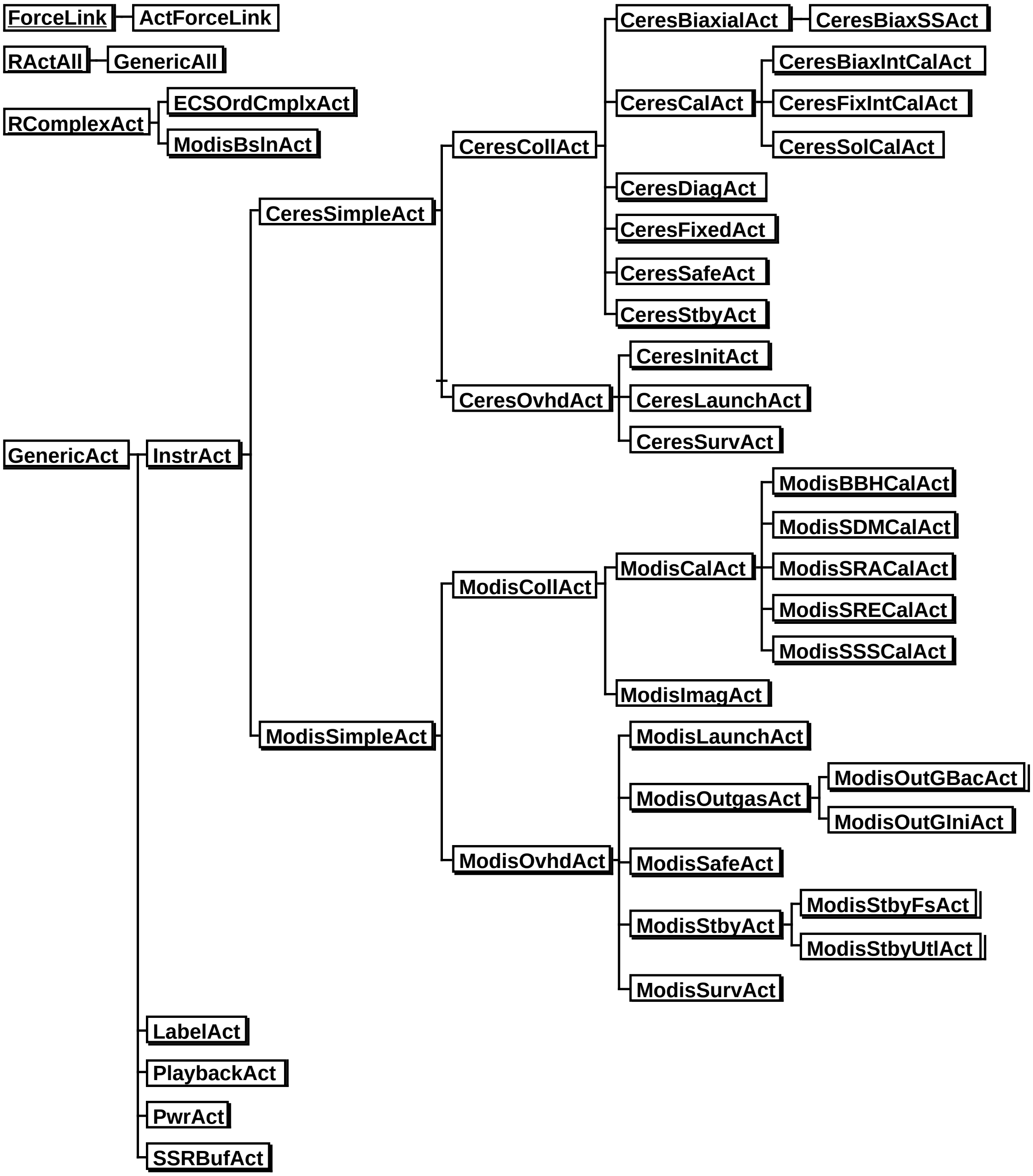


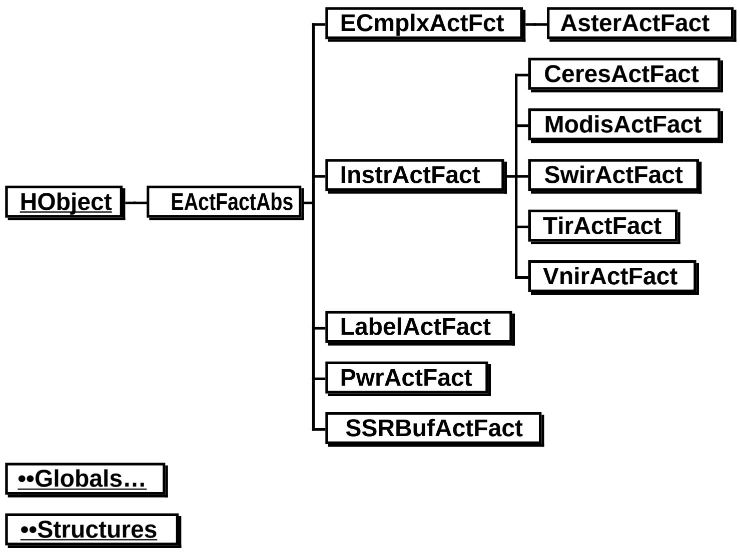
ECS FOS Planning and Scheduling:

Activity Class Library (eact) - Part 1 of 2



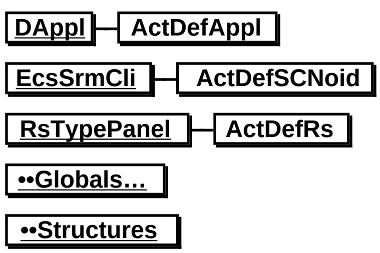
ECS FOS Planning and Scheduling:

Activity Class Library (eact) - Part 2 of 2



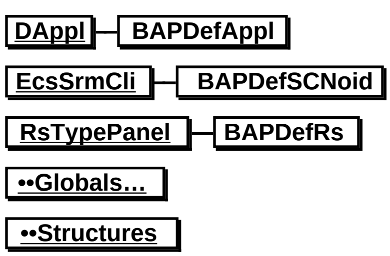
ECS FOS Planning and Scheduling:

Activity Configuration Class Library (eactcfg)



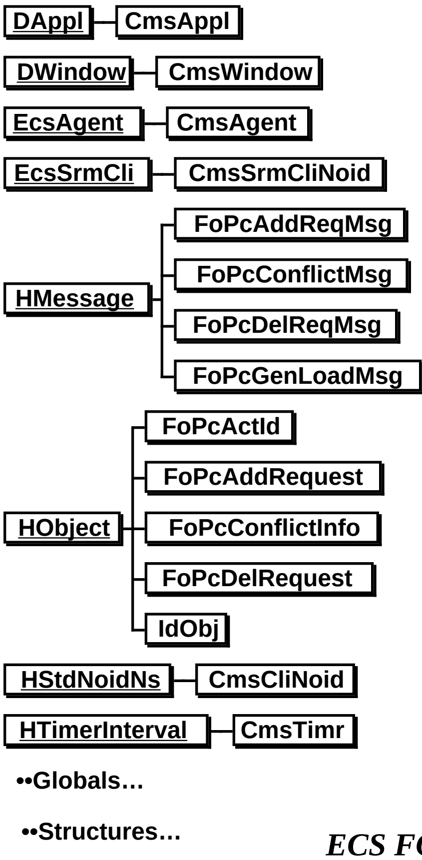
ECS FOS Planning and Scheduling:

Activity Definer Class Library (ead)



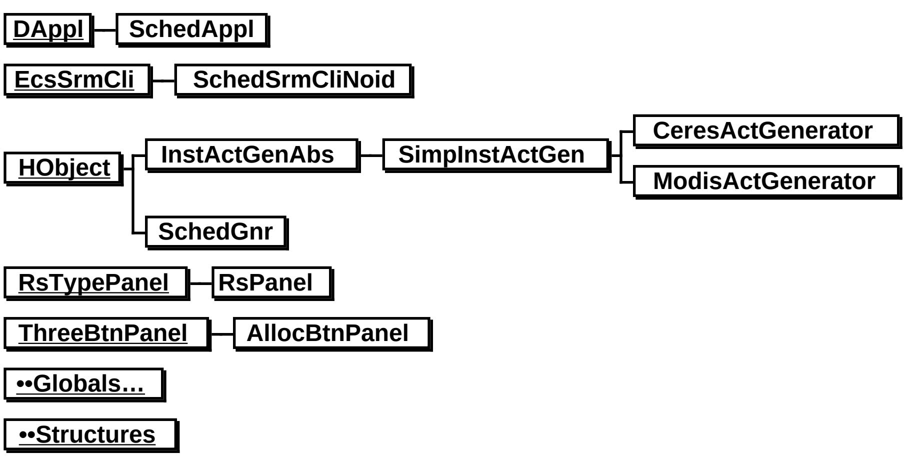
ECS FOS Planning and Scheduling:

Baseline Activity Profile Definer Class Library (ebd)



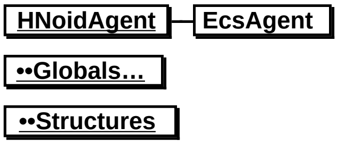
ECS FOS Planning and Scheduling:

Command Management Interface Class Library (ecms)



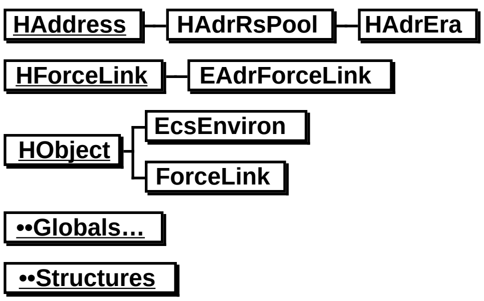
ECS FOS Planning and Scheduling:

Instrument Activity Scheduler Class Library (eias)



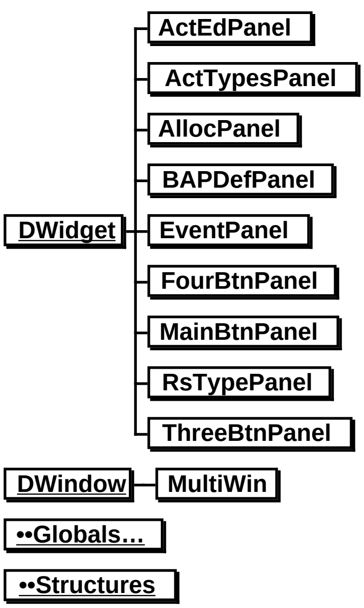
ECS FOS Planning and Scheduling:

Interprocess Communication Class Library (eipc)



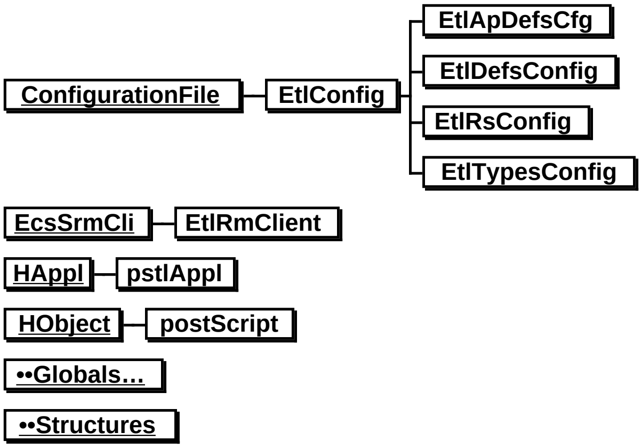
ECS FOS Planning and Scheduling:

Miscellaneous Class Library (emisc)



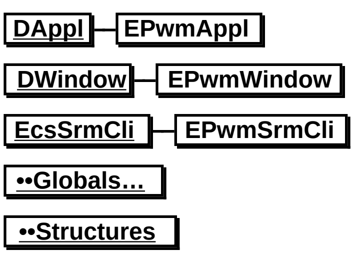
ECS FOS Planning and Scheduling:

Definer Panels Class Library (epanel)



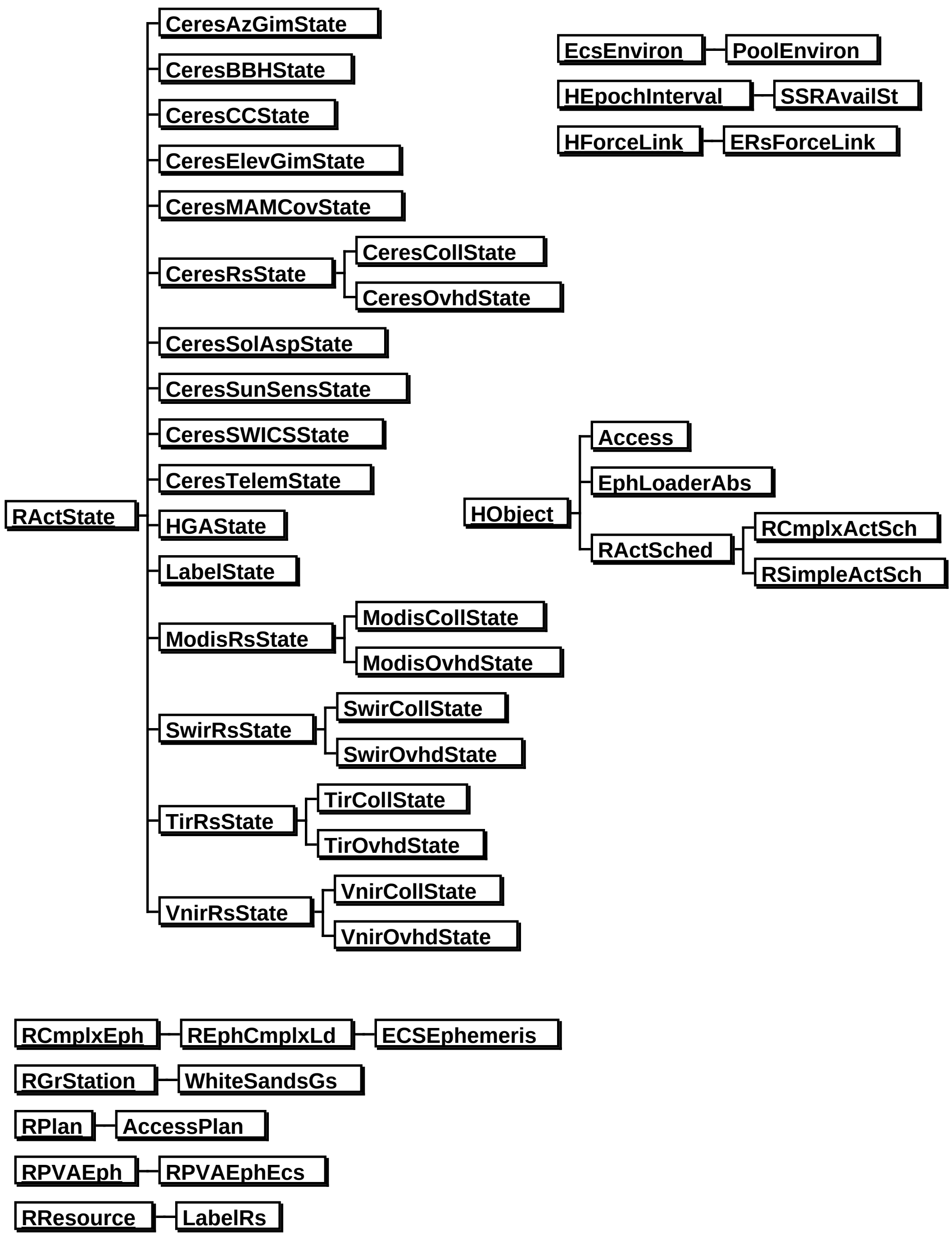
ECS FOS Planning and Scheduling:

Postscript Timeline Class Library (epstl)



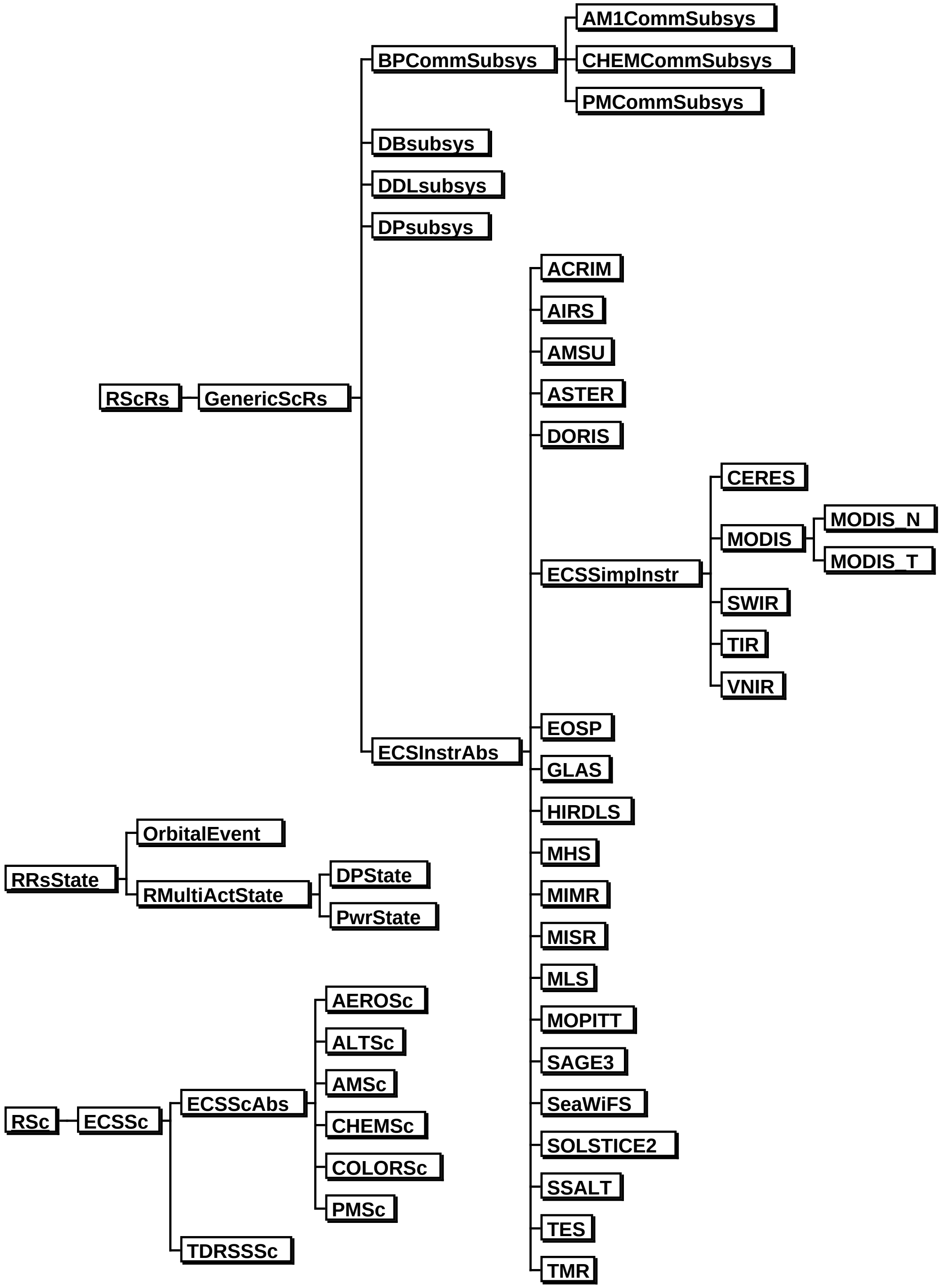
ECS FOS Planning and Scheduling:

Plan Window Manager Class Library (epwm)



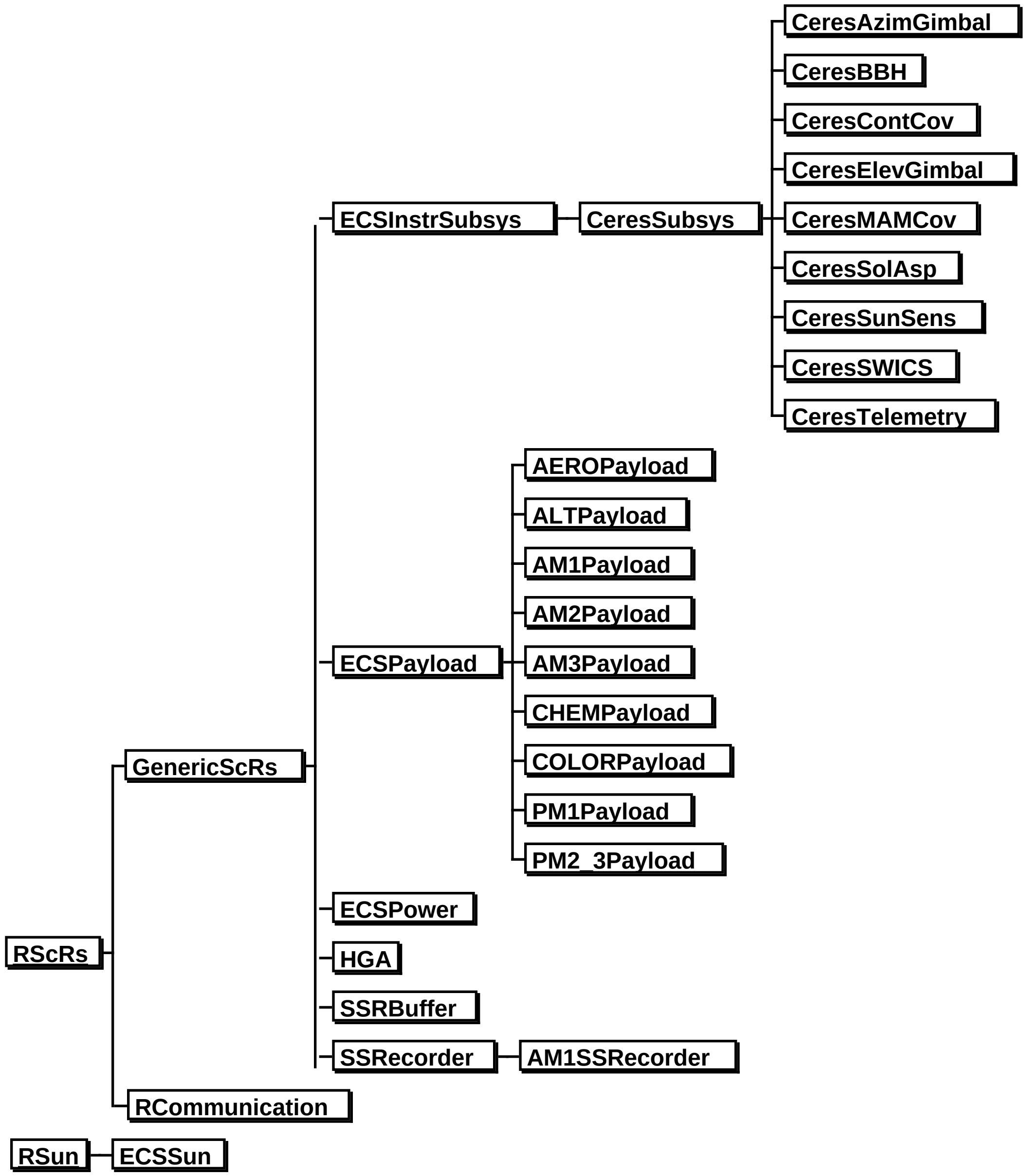
ECS FOS Planning and Scheduling:

Resource Class Library (ercl) - Part 1 of 3



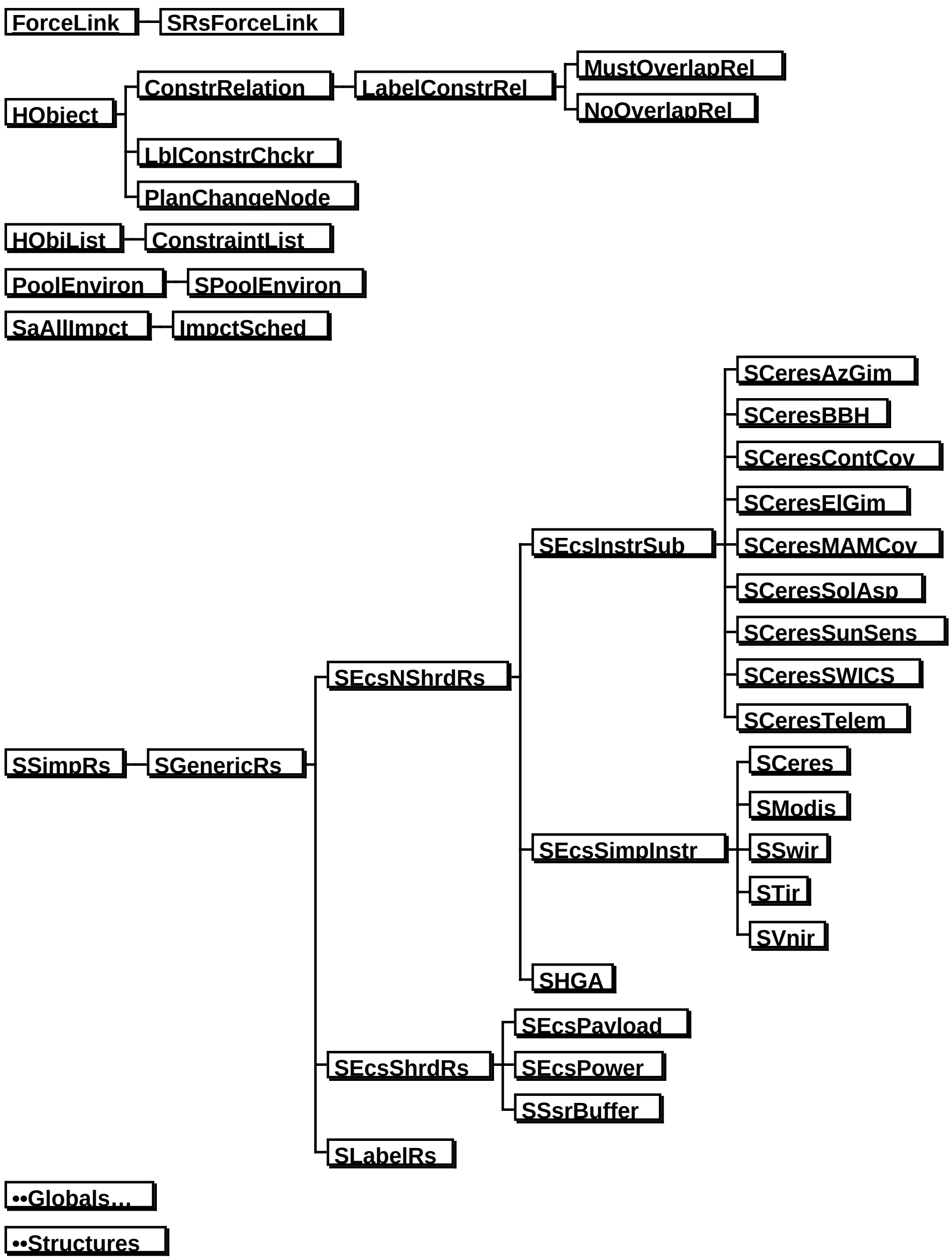
ECS FOS Planning and Scheduling:

Resource Class Library (ercl) - Part 2 of 3



ECS FOS Planning and Scheduling:

Resource Class Library (ercl) - Part 3 of 3



ECS FOS Planning and Scheduling:

Scheduling Resources Class Library (escl)

- Spt — ESpt
- SptAgent — ESptAgent
- SptWin — ESptWin
- ••Globals…
- ••Structures

ECS FOS Planning and Scheduling:

Plan Tool Class Library (espt)

- HAppl — RaAppl
- HSigHand — EraSigSave
- Srm — EcsSrm
- SrmNoid — EcsSrmNoid
- ••Globals…
- ••Structures

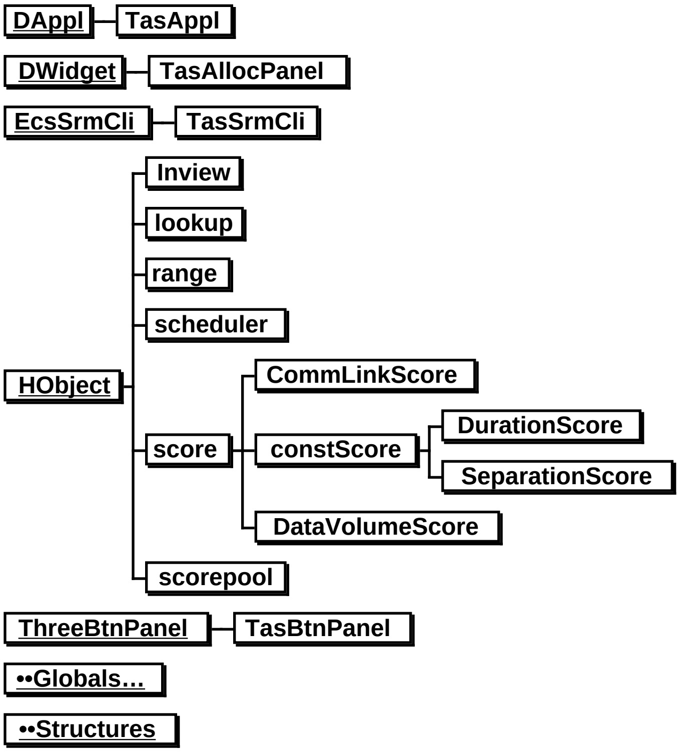
ECS FOS Planning and Scheduling:

Resource Model Class Library (esrm)

- HMsgCol — SMsgActPoolRsp
- SMsgStat
  - SMsgActSchRqst
  - SMsgGetActPool
  - SMsgRsNms
  - SMsgRsNmsRsp
- SrmCliNoid — EcsSrmCli
- ••Globals…
- ••Structures

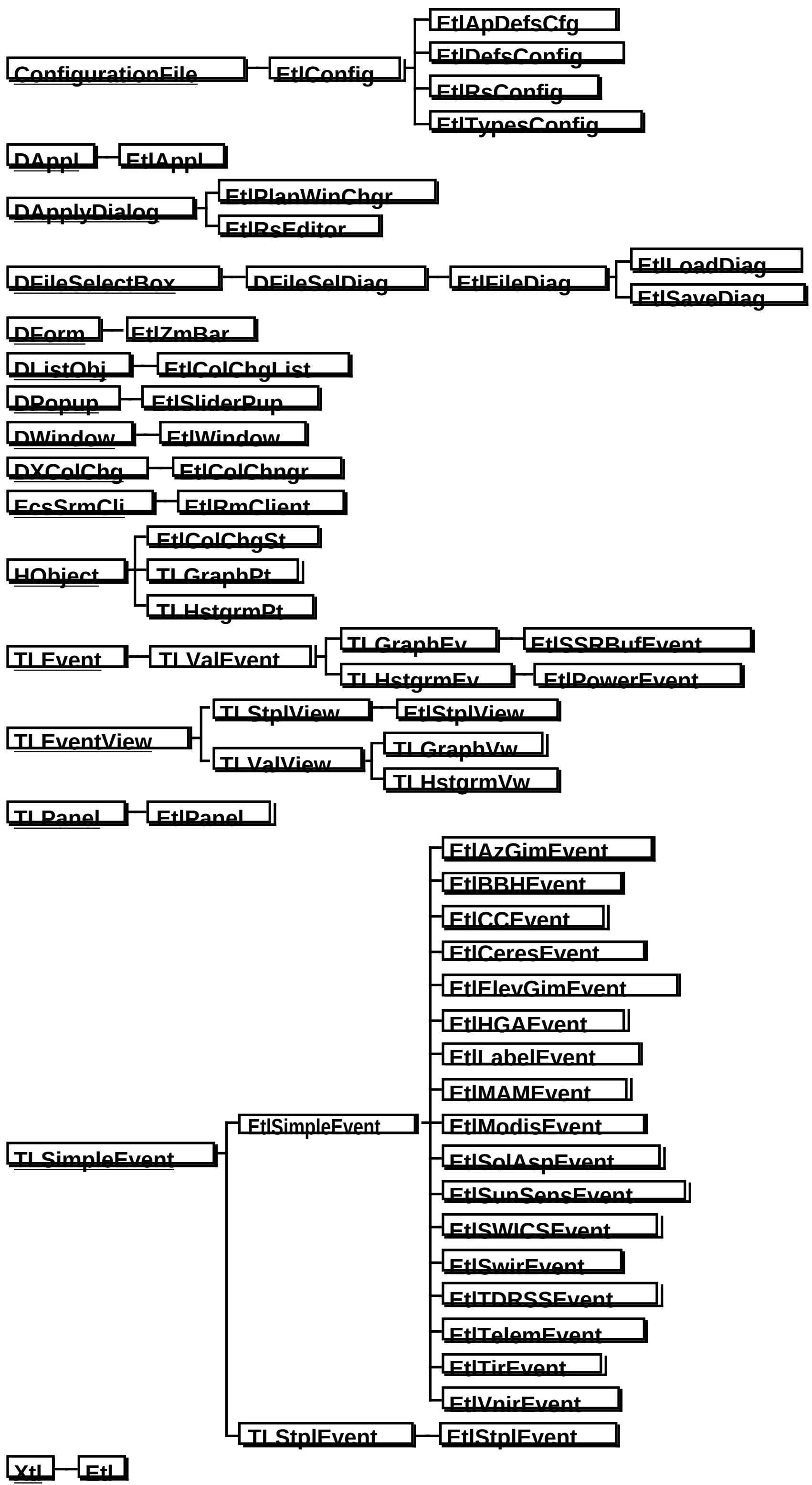
ECS FOS Planning and Scheduling:

Resource Model Client Class Library (esrmcli)



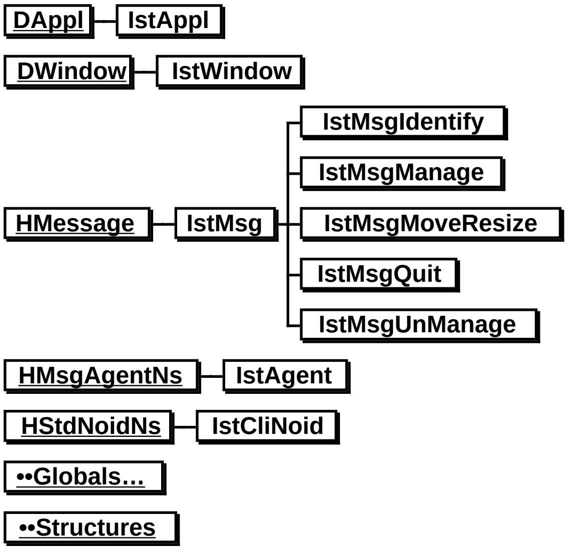
ECS FOS Planning and Scheduling:

Communication Contact Scheduler Class Library (etas)



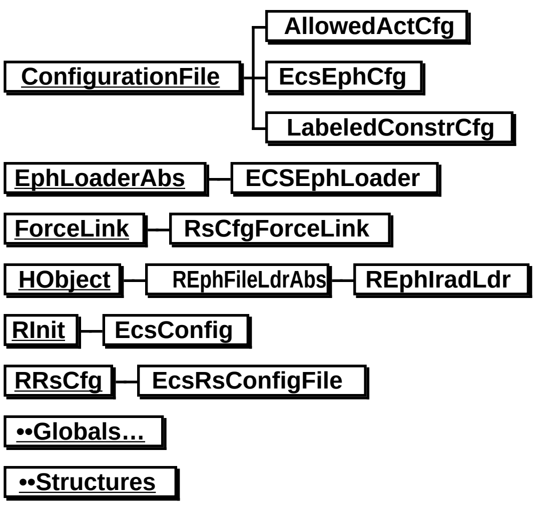
ECS FOS Planning and Scheduling:

Timeline Class Library (etl)



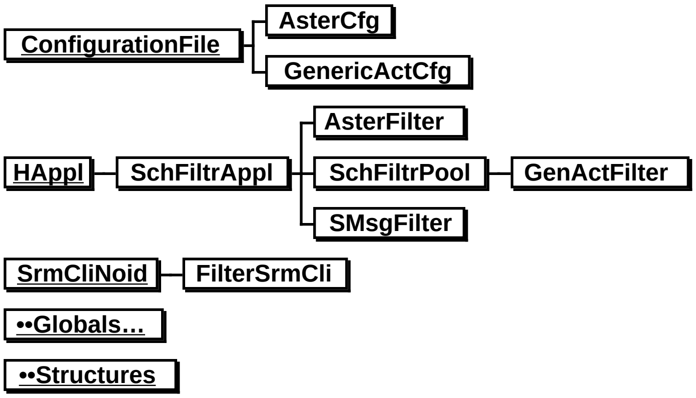
ECS FOS Planning and Scheduling:

Instrument Support Terminal Interface Class Library (ist)



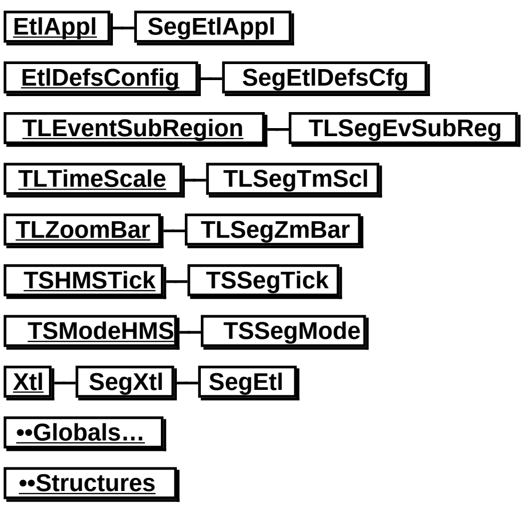
ECS FOS Planning and Scheduling:

Object Database Class Library (odb)



ECS FOS Planning and Scheduling:

Schedule Filter Class Library (schfiltr)



ECS FOS Planning and Scheduling:

Segment Timeline Class Library (segetl)

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Abbreviations and Acronyms

ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
BAP	Baseline Activity Profile
CERES	Clouds and Earth's Radiant Energy System
CMS	Command Management System
DAR	Data Acquisition Request
DAS	Detailed Activity Schedule
DCE	Distributed Computing Environment
ECS	EOSDIS Core System
EOC	EOS Operations Center
EOS	Earth Observing System
EOSDIS	Earth Observing System Data and Information System
FOS	Flight Operations Segment
GSFC	Goddard Space Flight Center
HCL	Hughes Class Libraries
HIPC	Hughes Inter-Process Communication
HMI	Human-Machine Interface
ICC	Instrument Control Center
IR&D	Internal Research and Development
IST	Instrument Support Terminal
JPL	Jet Propulsion Laboratory
MISR	Multi-angle Imaging Spectro-Radiometer
MODIS	Moderate Resolution Imaging Spectrometer
MOPITT	Measurements of Pollution in the Troposphere
NCC	Network Control Center
OPS	Onboard Payload Support
P & S	Planning and Scheduling
PCL	Planning Class Libraries
PI/TL	Principal Investigator/Team Leader

PRR	Prototyping Results Review
RCL	Resource Class Libraries
RPC	Remote Procedure Call
SCCS	Source Code Control System
SCL	Scheduling Class Libraries
SSR	Solid State Recorder
TCL	Timeline Class Libraries
TDRSS	Tracking and Data Relay Satellite System
TOO	Target Of Opportunity
XDR	External Data Representation